Section 5. Assessment of Potential Impacts to Covered Species and Their Habitats that May Result in Take

5.1 INTRODUCTION

Simpson has designed a conservation strategy to: (a) evaluate, and avoid or minimize, and mitigate the impacts of Simpson's operations and forest management activities on the Covered Species and other similarly situated species, (b) avoid jeopardy to the Covered Species and (c) contribute to conservation efforts for the Covered Species. For purposes of complying with the ESA, this Plan provides a particular focus on incidental take as provided by ESA Sections 9 and 10. As required for ITPs (but not explicitly for ESPs issued pursuant to CCAAs), this Plan is designed to minimize and mitigate the impacts of any incidental take of the Covered Species that could result directly from Covered Activities or indirectly from the environmental effects of such activities. The Plan is also designed to ensure that jeopardy will not result to any of the Covered Species as a result of any incidental take that is authorized pursuant to the ITP or ESP. As required for ESPs, the Plan is designed to contribute conservation benefits, which, when combined with the benefits that will be achieved if it is assumed that conservation measures also were implemented on other necessary properties, would preclude or remove a need to list the ESP Species. In addition to improving habitat conditions for the ESP species in the Initial Plan Area, many of the conservation benefits that will be provided the ESP species in this Plan are associated with measures designed to avoid or minimize and mitigate the impacts of incidental take. Therefore, although minimization and mitigation of the impacts of taking is not specifically mandated in the CCAA/ESP approval criteria, incidental take is still a principal focus of the Plan for ESP species as well as ITP species.

A more detailed literature review of the potential effects of timber management is provided in Appendix E. The effects of timber harvest on aquatic life depend on many factors and studies often result in contradictory results (Spence et. al. 1996). Factors that may influence responses include: aquatic species' diversity and adaptability, physical and vegetative conditions and harvest methods, biotic interactions and wide-ranging migratory behaviors can act to reduce impacts of habitat alterations, independent impacts that can accumulate, or interact collectively resulting in compensatory or synergistic responses, and large natural (catastrophic) events that create variable baseline conditions confusing other smaller scale variability.

Not all forest management activities and their effects have the potential to cause "take" of Covered Species. The term 'take' means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct (16 USC section 1532(19)). Harm in the definition of "take" means an act which actually kills or injures fish and wildlife. Such an act may include significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding or sheltering (50 CFR part 222.102; also see 50 CFR part 17.3). Of the Covered Activities, Simpson's timber harvesting operations and the road construction maintenance or use, as well as construction, maintenance and use of landings, culverts and crossings associated with such harvesting have the greatest potential to cause environmental effects—both individual and cumulative—which, in turn, could result in take of Covered Species.

This Section describes the Covered Activities and associated environmental effects that have the greatest potential to cause take of Covered Species. These include not only individual environmental effects that could result in take, but also cumulative effects, i.e., individually minor environmental effects that themselves would not cause take but, when combined with other similar effects that are closely related temporally and spatially, could cause take of Covered Species. In addition, this Section discusses the potential impacts of such taking on the Covered Species if it were to result. The conservation measures described in Section 6 were designed to avoid, minimize, and mitigate these potential impacts of taking, as well as other environmental effects, in addition to providing other conservation benefits. The measures address the potential for each type of impact or cause of take to be a significant limiting factor for each of the species individually and the Covered Species collectively.

5.2 POTENTIAL FOR ALTERED HYDROLOGY

The basic components of the hydrologic cycle are precipitation, infiltration, evaporation, transpiration, storage and runoff. In the Pacific Northwest, where annual precipitation is highly seasonal, the timing, quantity and quality of rain and snowfall have great influence on salmonid life histories and have the potential to impact the aquatic phase of headwater amphibians. Thus, the effects of timber harvest activities on the hydrologic cycle are important. This discussion reviews how timber management activities may alter the hydrologic cycle, considers the potential for such altered hydrology to cause take of Covered Species, and discusses the possible impacts of such take on the Covered Species

5.2.1 Potential Effects of Covered Activities

Timber harvest temporarily reduces or eliminates leaves and stems. The surface area of this vegetation normally intercepts precipitation for short-term storage that is either evaporated or released as drip. The loss of forest vegetation also reduces the amount of water extracted from the soil by root systems via evapotranspiration and increases soil moisture and pieziometric head. This was demonstrated by Keppeler and Brown (1998) after harvest of second growth redwood forest. Such increases in soil moisture can contribute to increased risk of mass wasting (Sidle et al. 1985, Fig. 10; Schmidt et al. in press). This is discussed further in Section 5.3.2.2. The effect of any reduction in evapotranspiration is typically short lived (3-5 years), as rapid regrowth of vegetation may consume more water than pre-timber harvest amounts (Harr 1977). This is likely to be true in redwood forests as well, in part owing to the stump-sprouting habit of redwood.

The primary effects of timber harvest on surface water hydrology pertain to (Spence et. al. 1996):

- peak flows,
- low (base) flows,
- water yield, and
- run-off timing.

Paired watershed experiments to measure changes in flow following timber harvest have been conducted north of the project area (Oregon) and south of the project area (Mendocino County, California). In relatively small watersheds (about 150 to 1200 ac), peak flow magnitude following harvest tends to increase, with the largest increases occurring in smaller runoff events (less than one-year) (Beschta et al. 2000, Ziemer 1998). For one-year recurrence interval events, peak flow magnitude increased 13-16%; these increases were 6-9% for five-year recurrence interval events (Beschta et al. 2000). At Caspar Creek in Mendocino County, increases in peak flow magnitude were about 10% for two-year storm recurrence interval events. The effect of timber harvest on peak flows generally diminishes with increasing watershed size and with increasing flow magnitude (Beschta et al. 2000, Ziemer 1998). Effects for larger watersheds are difficult to asses because they are influenced by many additional factors, including regulatory controls on the proportion of the landscape that can be harvested at any given time (e.g., clearcut adjacency and rotation age restrictions adopted by the Board of Forestry) and the extreme variability introduced when attempting to study large basins that experience relatively infrequent major hydrologic events.

The extent of harvest-related changes in hydrology within a watershed may be affected by whether the system is rain or snow dominated. Keppeler and Ziemer (1990, as cited by Spence et al. 1996) found increased summer flows in a Northern California stream following timber harvest but this diminished after five years. In many cases, for rain-dominated systems in the Coast Range, increases in peak flows (particularly in the fall) following timber harvest, are documented (Spence et al. 1996). The principal increases in peak flows following timber harvest in rain-dominated systems are likely as a result of reduced interception and evapotranspiration rates resulting from the loss of vegetation and the more rapid routing of water to stream channels because of soil compaction and roads (Spence et. al. 1996, Ziemer 1998). In contrast, generally in snow-dominated systems in the Northwest, peak flows have been shown to change little following timber harvest. In transient-snow systems studies have been somewhat inconclusive as to the effects of timber harvest on peak flows. However, Harr (1986 as cited by Spence et. al. 1996) found that in transient-snow systems where harvest had resulted in increased peak flows, the removal of vegetation increased the delivery of water to the soil from the snow-pack during rain-on-snow events. Other research has shown that increased snow melt rates and delivery of water to the soil occurs during rain-on-snow events accompanied by relatively high temperatures and wind speeds (Coffin and Harr, 1992, as cited by Spence et. al., 1996). The commercial timberlands within the 11 HPAs are entirely rain-dominated. Therefore, the effects of snow-dominated and rain-on-snow hydrology are not an issue for this Plan.

Timber harvest activities that compact or disturb the soil can reduce the infiltration capacity of soils and alter the process of subsurface water movement. Compacted soils found on roads and landings are relatively impermeable and water runs off them quickly.

Inboard ditches along truck roads not only collect and concentrate surface runoff, but also intercept subsurface flow and bring it to the surface (Furniss et al. 1991). Reduced evapotranspiration, reduced soil infiltration capacity, and the interception of surface flow may lead to increases in surface runoff, peak stream flows, and sediment inputs to watercourses.

Water and sediment from roads can enter stream channels by many mechanisms (Furniss et. al. 2000):

- Inboard ditches that deliver road drainage to stream channels at truck road watercourse crossings,
- Inboard ditches that deliver flow to culverts, road drainage dips or water bars with sufficient discharge to create a gully or generate a sediment plume that extends to a stream channel,
- Improperly spaced or located road drainage structures that discharge sufficient water to create a gully or generate a sediment plume that extends to a stream channel, and
- Roads located close enough to a stream that fill slope erosion or fill failures result in sediment discharge in to stream channel.

Some studies have shown that forest roads increase peak flows and sediment inputs to small watersheds when as little as 2.5%-3.9% of the watershed is composed of road surfaces (Harr et al. 1975; Cederholm et al. 1980; King and Tennyson 1984). Studies reporting increases in water yield from logged watersheds indicated that these increases were most evident in the start of the fall/winter wet season when rain quickly filled soil pore spaces in the logged areas and then ran off as surface flow. Differences were less apparent later in the rainy season as soil under mature canopies also became saturated, and runoff from harvested and un-harvested areas became similar (Hibbert 1967; Harr et al. 1979). Other studies have also shown that road construction and some timber harvest activities may lead to increased flows in the first (fall/early winter) small rain events but have no significant effect on larger flow events (Wright et al. 1990; Johnson and Beschta 1980).

Many paired watershed studies have found increases in summer base flow and total water yield (Bosch and Hewlett 1982), particularly in humid coniferous forest types. Studies north of the HPAs in southwest Oregon (Harr et al. 1979) and south of the HPAs at Caspar Creek in Mendocino County (Keppeler 1998) found increases in both total water yield and seasonal base flows.

5.2.2 Potential Effects on Covered Species

The effects of temporary changes in watershed yield, peak flow magnitude and timing, and summer base flows on salmonids and key salmonid habitat characteristics are difficult to assess. The life-cycles of salmonids species have adapted to temporal variations in flow conditions by timing the phases of their life cycles to take advantage of seasonal discharges characteristics (Sullivan et. al. 1987). Increased runoff in the early part of the rainy season may, in some cases, benefit salmonids by reducing water temperatures, improving water quality, and providing more flow for immigrating adult spawners. However, a harvest-related increase in peak flows may increase the number of times that channel substrates are mobilized by storm events and potentially damage developing eggs and alevins in redds (Hicks et al. 1991 as cited by Spence et. al., 1996). Damage to developing eggs and alevins in redds would constitute take. Channel forming flows may occur more frequently as a result of an increase in peaks flows and thus habitats for spawning, rearing and foraging may be affected, either adversely or beneficially. Increased peak flows may also affect the survival of over-wintering juvenile salmonids by displacing them out of preferred habitats. Displacement of juveniles could cause take if the displacement impairs individual sheltering needs to the extent of killing or injuring individuals. These flow increases could have marginal beneficial effects by increasing available aquatic habitat. Short-term increases in summer baseflows may improve survival of juveniles (Hicks et. al. 1991 as cited by Spence et. al., 1996) and increase the amount of aquatic habitat. However, these effects are proportional to harvested area and diminish with regrowth of forest vegetation, so the effects are greatest for small watersheds.

The specific effects of altered hydrology on the amphibian Covered Species and their habitat are not known currently and are equally difficult to assess. Simpson is not aware of any studies that have addressed this potential effect on species such as the torrent salamander or tailed frog. The speculation is that, in general, these headwater species would be less likely to be affected relative to salmonid species that spawn and rear lower in the watershed. Tailed frog habitat overlaps with the upper reaches of salmonid habitat, and it is possible that increases in peak flow during winter may have a negative impact on larval tailed frogs. This could occur through entrainment of the substrate, which may displace or directly harm the larvae. Further, in extreme circumstances, such increases in peak flow could cause take, which may result in local declines in tailed frog populations. However, this would not likely result in long-term changes in the habitat for the species, and therefore it would not likely to result in major changes in populations of the species. Increases in summer low flows due to harvesting activities may be beneficial to larval tailed frog populations, especially during drought years, so it is not possible to know if the overall impact of altered hydrology on tailed frog populations is positive or negative.

Southern torrent salamanders live in seeps and springs and the uppermost reaches of watercourses, and as a result increases in peak flow would be unlikely to have any negative impact on this species. Limited field observations of torrent salamanders during high flows suggest that they simply move to the margins of the channel and would not be impacted by entrainment of the substrate. Since torrent salamanders live in aquatic sites with minimal flows, it seems likely that increases in summer low flows would be beneficial for this species. However, they live in association with Pacific giant salamanders that have the potential to prey on or compete with torrent salamanders. Torrent salamanders specialize in utilizing sites with the most minimal flows, so biotic interactions may change with increases in summer low flows. All of these considerations are highly speculative, and Simpson does not believe it is possible to predict whether or not altered hydrology would have an impact, positive or negative, on southern torrent salamanders.

Increased runoff and peak flows and decreased infiltration capacity of soils due to timber management and road construction are also correlated with increased sediment inputs to watercourses (Harr et al. 1975; Cederholm et al. 1980; King and Tennyson 1984). The negative effects of increased sediment inputs on the Covered Species and their habitats are described in Section 5.3.

To summarize, the extent to which watershed hydrology is altered by timber harvesting activities and, similarly, the extent to which such altered hydrology may negatively impact the Covered Species, is a function of the amount and timing of those activities in a sub-basin or watershed. Given the cumulative relationship among those activities and this type of environmental effect, it is difficult to assess the potential for these activities to cause altered hydrology itself, and it is also difficult, in turn, to evaluate the potential for altered hydrology to cause take of the Covered Species. For example, management-altered hydrology has the potential to harm both the early stages of development (eggs and alevins) as well as over-wintering juvenile salmonids. On the other hand, the effects of altered hydrology may be beneficial for adults returning to spawn in the fall and summer juvenile populations. Therefore, depending on which potentially limiting factors are actually limiting for salmonid production in a given sub-basin, some levels of altered hydrology may be beneficial. However, if other factors are limiting, altered hydrology may cause take and lead to local declines in populations of salmonids. For instance, if summer water temperatures are limiting, increases in summer base flows could be beneficial. In contrast, increases in winter peak flows could cause take and lead to local declines if spawning or over-wintering survival rates were limiting. In conclusion, the potential impacts of altered hydrology are highly complex, and although it has the potential to cause take that could lead to local declines in populations of the Covered Species, the actual impact of various levels of altered hydrology remain unknown. In any event, as a means of avoiding or minimizing and mitigating any negative impacts that could result from altered hydrology, the Plan provides measures to minimize the potential for harvest operations to cause altered hydrology.

5.3 POTENTIAL FOR INCREASED SEDIMENT INPUT

Timber harvest and the construction and use of the associated road system have the potential to increase sediment inputs. Increased sediment inputs from such activities can reduce the quality of aquatic habitats for all six Covered Species through reduced depth of deep water habitats (primarily pools), increased embeddedness of gravel and cobble substrates, and the effects of chronic turbidity on the Covered Species and thereby result in incidental take. Sediment inputs that result in take can be caused by either a single activity or by the combination of minor inputs from multiple activities that combine spatially and temporally to become collectively significant.

Hillslope erosion, sediment delivery to streams, and sediment transport and sorting within streams are natural dynamic processes that are responsible for creating aquatic habitat for the Covered Species. Steep, geologically young, coastal mountains are especially prone to high natural rates of erosion and the Covered Species have evolved in this environment. However, excessive inputs of sediment (both coarse and fine) from a combination of anthropogenic and natural sources can overload a stream's ability to store and transport sediment, reducing the quality and quantity of aquatic habitat for the Covered Species. (See Appendix E for a more detailed discussion.)

5.3.1 Potential Effects of Covered Activities

The variations in bedrock geology, tectonics, and associated geomorphic characteristics in northern California result in different erosion and sedimentation conditions in different stream reaches (the geology and geomorphology of the area where the Plan will be implemented are described in Section 4.2). Sediment production (erosion) may be highly variable depending on the presence or absence of Franciscan mélange and other geologic formations that contain abundant deep landslides and earthflows and locally extensive shearing and faulting in sedimentary rocks. In contrast to regions where active earthflows and rockslides contribute massive amounts of sediment to streams, more competent sandstone units of the Franciscan Formation deliver less sediment. In these areas, hillslope geomorphology is characterized by V-shaped valleys with steep hillslopes where debris slides are the primary mass wasting process. Where active deep-seated landslides do not contribute a major component of sediment inputs, sediment yields are approximately an order of magnitude (a factor of 10) lower (Kelsey 1982; Lisle 1990). In addition, the impact of the covered activities on potential sediment increases is also variable. Based on data presented in Appendix E, management-related erosion at the watershed scale typically induces increases in erosion ranging from about 30% to over 300%.

5.3.2 Sediment Sources and Erosion Processes

Sediment of varying size from the smallest fines to large boulders can be generated from a variety of different sources involving different erosion processes. One such process, surface erosion, tends to generate smaller particles sizes, and is a two-part process in which particles are first detached and then transported downslope. The two hydrologic processes that transport surface erosion are channelized erosion by constricted flows (rilling and gullying) and sheet erosion in which soil movement is non-channelized (rolling and sliding) (Swanston 1991). Increases in channelized and non-channelized erosion occur when the infiltration capacities of soils are reduced by management activities, large storm events or fires. Chamberlain et al. (1991) reported that the potential for surface erosion is directly related to the amount of bare soil exposed to rainfall and runoff. A study in Redwood National Park indicated that higher erosion rates tended to occur where rill erosion was more common, which was associated with tractor-harvest, and to a lesser extent, cable yarding, on schist soils (Marron et al. 1995).

In general, surface erosion does not account for a large portion of the total sediment budget in a watershed. Hagans and Weaver (1987) analyzed the data used by Marron et al. (1995), as well as data on percent bare soil following harvest and data on sediment delivery to streams from surface erosion processes on logged areas, including skid trails, for the lower Redwood Creek basin for the period c. 1954-1980, and concluded that only 4% of erosion was caused by sheet and rill erosion. Rice and Datzman (1981) conducted detailed surveys in northern California of 102 harvested plots averaging about 11 acres in size over a range of geologic and slope conditions. In aggregate, they found that two-thirds of the observed erosion was associated with roads, landings or skid trails. Surface erosion in the form of rills and gulleys not associated with roads, landings or skid trails (i.e. harvested areas) accounted for about five percent of total erosion.

Mass wasting is another process that has the potential to produce large amounts of both coarse and fine sediment. In steep mountainous terrain, mass soil movement is a major type of hillslope erosion and sediment source in watersheds (Sidle et al. 1985, Swanston 1991). The frequency and magnitude of mass soil movements is governed by hillslope gradient, level of soil saturation, composition of dominant soil and rock types, degree of weathering, type and level of management activities, and occurrence of climatic or geologic events.

Mass soil movements are usually episodic events and tend to contribute significant quantities of sediment and organic debris to stream channels over time intervals ranging from minutes to decades (Swanston 1991). The resultant sediment and organic debris may have a profound effect on a stream channel including large increases in coarse and fine sediments, shifts of existing bed-load, and increases in woody debris that can lead to partial or complete stream blockages.

Forest management practices can affect slope stability and increase the risk of mass wasting by changing vegetative cover, hillslope shape, and water flow above and below the ground surface. Different forest management operations have distinct effects on the factors that control slope stability. For two of the major components of forest management operations—road construction (and to a lesser extent skid trail construction) and harvesting trees—the potential consequences with respect to shallow landslide processes and slope stability are relatively well known. Road and skid trail construction may:

1. Create cut slopes and fill slopes too steep to be stable,

2. Result in deposition of sidecast material (spoils) that overburdens and/or oversteepens slopes, and

3. Divert and/or concentrate both surface and subsurface runoff.

While harvesting trees may:

1. Reduce effective soil cohesion by disrupting networks of interlocking roots from living trees in the “window” of reduced root reinforcement up to about 15 years, and

2. Increase soil moisture by reducing interception of precipitation and evapotranspiration of soil water. This is significant because greater soil moisture reduces the amount of precipitation from a given storm event required to cause soil moisture levels to reach a critical level.

The actual influence of specific forest management activities on slope stability, however, depends on the design and construction of the road network, density of residual trees and under-story vegetation, rate and type of revegetation, topography, material strengths, patterns of surface and subsurface flow, and patterns of water inflow (Sidle et al., 1985; Yoshinori and Osamu, 1984). Landslide rates associated with roads are generally much greater than landslide rates associated with timber harvest alone (Sidle et al. 1985). However, separating the effects of timber harvest activities from the associated yarding, construction, maintenance and use of skid roads and the forest road system may be difficult. Further, the results vary between watersheds. Most studies indicate that the sediment inputs from timber harvesting alone are less than those of the associated road network (Sidle et. al. 1985; Raines and Kelsey 1991; Best et al. 1995). (See Appendix E for a more detailed discussion.)

Deep-seated landslides also have the potential to produce large amounts of both coarse and fine sediments. Natural mechanisms that may trigger deep-seated landslides include intense rainfall, earthquake shaking, and erosion of landslide toes by streams. It is generally acknowledged that deep-seated landslides (earthflows and rockslides) may be destabilized by undercutting of the landslide toe (e.g. by streambank erosion or excavation of road cuts), by adding significant mass to the landslide body (e.g. disposing of spoils from grading or excavation projects), or by significantly altering the groundwater conditions in a landslide (e.g. diversion of road drainage into head scarps or lateral scarps) (TRB 1996, Ch. 16). Deep-seated landslides may also be affected by these hydrologic changes associated with reduced evapotranspiration reduced canopy interception during rainstorms (DMG 1997). Potential increases in groundwater associated with timber harvest in areas upslope of active deep-seated slides may also be important.

The relatively few regional empirical landslide studies have produced varying conclusions on the effect of timber harvesting on earthflow stability (i.e. deep-seeded landslides). Short-term increases in ground displacement following clear cutting have been documented on several active earthflows in the Coast Range and Cascades of Oregon (Pyles et al. 1987; Swanson et al. 1988; Swanston et al. 1987; Swanston 1981). In contrast, work by Pyles et al. (1987) on the Lookout Creek earthflow in central Oregon concluded that timber harvesting was unlikely to induce a large increase in movement, primarily because the slide was well drained.

In summary, previous studies suggest that forest management activities can potentially increase the occurrence or rate of movement of deep-seated landslides. Recognition of active landslides and avoidance of management practices that are known to increase risks of movement can reduce the overall risk of erosion associated with deep landslides. Site-specific conditions pertaining to individual slides will always be important in development of site-specific forest management plans; nevertheless, substantial uncertainty is likely to remain regarding predicted effects of management on slide activity. Deep landslides are relatively common, naturally occurring geologic features in northern California that will continue to generate substantial quantities of sediment delivered to streams, regardless of management influences.

The preceding discussion indicates that erosion from roads, including landslides (mass wasting), gullying caused by improper drainage, and rainsplash and sheetwash erosion on road and cutslope surfaces, are generally the most significant component of erosion related to forest harvest activities. Timber harvesting operations have historically relied on an extensive network of unpaved roads and necessitated building new roads to access portions of timberlands being harvested. Roads are recognized as a significant source of sediment inputs to watersheds (as described above; see also Gibbons and Salo 1973, Weaver and Hagans 1994). Sediment input from roads can occur through both surface erosion and mass wasting.

Research has shown that road construction for timber harvesting can cause significant increases in erosion rates within a watershed (Haupt 1959; Gibbons and Salo 1973; Beschta 1978; Rice et al. 1979, Cederholm et al. 1980; Reid and Dunne 1984; Swanson et al. 1987; Furniss et al. 1991). Roads can affect watersheds by modifying natural drainage patterns and by accelerating erosion and sedimentation, potentially altering channel stability and morphology. If proper construction techniques and maintenance practices are not followed, sediment increases following road construction can be severe and long lasting. Gibbons and Salo (1973) concluded that the sediment contribution per unit area from forest roads is usually greater than that contributed from all other timber harvesting activities combined. Cederholm et al. (1980) reported a significant positive correlation between the percentage of basin area in road surfaces and percentage of fine sediments (less than 0.85 mm) in spawning gravels.

Forest road systems and their associated stream crossings in steep coastal watersheds have the potential to be a major cause of mass soil movements (Best et. al. 1995; Sidle et al. 1985; many others). Road inventories conducted in the Pacific Northwest have reported that erosion from older roads may contribute 40 to 70 percent of the total sediment delivered to the system (Best et al. 1995; Durgin et al. 1988; McCashion and Rice 1983; Raines and Kelsey 1991; Rice and Lewis 1991; Swanson and Dryness 1975).

The actual increases in hillslope failures due to roads that are observed in any given watershed are affected by variables such as hillslope gradient, soil type, soil saturation, bedrock type and structure, management levels and road placement. The literature suggests that road placement is the single most important factor, because it affects how much the other variables will contribute to slope failures (Anderson 1971; Larse 1971; Swanston 1971; Swanston and Swanson 1976; Weaver and Hagans 1994).

5.3.3 Sediment Transport Processes

There are three modes of sediment transport in stream channels: bedload, intermittent suspended load, and suspended load. Although each of these processes corresponds to a generally consistent size range of sediment, the processes occur over a physical continuum, and that there is substantial overlap among these modes of sediment transport. Depending on the intensity (i.e. velocity) of stream flow, the sediment transported in one mode may be transported in another mode. Many textbooks provide a description of sediment transport mechanics (e.g. Richards 1982, Raudkivi 1990, Yang 1996).

The typical size of material transported primarily as bedload in upland streams is gravel (2 mm to 64 mm diameter) and cobble (64 mm to 256 mm diameter). Larger material (boulders) are also transported as bedload, however, sediment particles of this size move relatively slowly and are more likely to form nodes of stability in stream channels (i.e. boulder steps or transverse bars, Grant 1990).

Bedload is transported by sliding, rolling, or skipping along the streambed. Bedload particles are rarely found in the water column far above the bed. Bedload sediment is typically routed through mountain channel systems slowly, with average annual transport distances from tracer studies of about 300 ft, ranging from about 60 to 1500 ft (NCASI 1999, p. 289). The volume of bedload sediment deposits is typically large in comparison with the annual transport rate.

Bedload sediment is broken and abraded as it collides with other sediment clasts on the bed or in transport; this gradual process of breakage and declining size is known as attrition. The attrition process converts a portion of the bedload to suspended load as larger sediment clasts produce smaller sediment particles. The attrition rate is usually estimated as a function of transport distance in the channel network. The magnitude of attrition varies, but as much as half of bedload material may be converted to suspended sediment over transport distances of about 20 km (Collins and Dunne 1989). Where bedrock is extremely weak (e.g. Wildcat Group rocks near Humboldt Bay), however, the attrition rate may be much higher, and where bedrock is relatively strong, the attrition rate much lower.

Intermittent suspended load (also called “saltation load” by Raudkivi (1990)) is typically comprised of fine gravel and coarse sand. It is transported partly in contact with streambed, and partly in suspension, depending on flow intensity and local channel morphology. These sediment sizes are often found in sorted deposits in the lee of channel obstructions or in pools, and are typically finer than typical median grain size on the surface of point bars and alternate bars. Intermittent suspended load is transported through channel systems more quickly, provided it is not deposited underneath coarse armor layers of bed and bar deposits. The typical annual velocity of intermittent suspended load is between that of bedload and suspended load, and is on the order of 1000’s of ft to miles.

Sand, silt and clay sizes (< 2 mm diameter) comprise the suspended sediment load in most upland stream systems. The sand fraction (> 0.06 mm and < 2 mm) is often a major constituent of the intermittent suspended load and a substantial constituent of the bedload. In many low-gradient rivers, sand is the dominant component of the bedload. Such conditions are found at the mouths of several coastal watersheds in northern California.

Suspended load is transported in suspension in the water column in relatively low-intensity flows. It typically is transported through the channel system rapidly; sediment velocity for suspended load is nearly equal to water velocity. If suspended sediment is present in or on the margins of channels it will be entrained rapidly with increasing stream discharge. This suspended sediment can be subsequently deposited in low-velocity areas downstream as stream discharge declines. Sediment of this type is rarely deposited in large quantities within the streambed in upland channel networks except in low-velocity environments such as unusually low gradient or hydraulically rough reaches, channel margins, side channels, and behind flow obstructions.

Much of the suspended load is removed from the upland stream system very rapidly and is deposited in floodplains, estuaries and offshore marine environments. Suspended load accounts for about 70 to 90% or more of the total sediment load in northern California watersheds. This includes the suspended load and, depending on measurement technique, some portion of the intermittent suspended load.

Suspended load transport in many northern California streams (e.g. Caspar Creek, Lewis 1998) is correlated with turbidity (an optical characteristic of water quantifying its clarity or cloudiness). Hence, the supply of suspended load sediment size fractions is the chief control on stream turbidity, a measure of water quality used by the California Regional Water Quality Control Board in its Basin Plan for northern coastal California. The silt and clay fraction in the suspended load strongly influences turbidity; hence control of sediment sources rich in silt and clay will provide the greatest reduction in turbidity.

The relationship between sediment inputs to a channel network and sediment transport capacity of the channel network will have a strong influence on channel sedimentation status (e.g. Montgomery and Buffington 1993, Buffington and Montgomery 1999). For example, channel systems that are said to be “transport-limited” have a high sediment supply such that supply is greater than the streams sediment transport capacity. The channel bed in transport-limited channels is expected to be relatively fine, typically composed of finer gravel and sand with little armoring of the bed surface. Transport-limited channels may be found where there are abundant sediment inputs (e.g. recent concentrated inputs from landslides) or where channel slope declines rapidly (e.g. where a relatively steep confined channel reaches a broad valley with lower channel gradient). In contrast "supply-limited" systems have a high sediment transport capacity relative to sediment supply. The channel bed of supply-limited systems is expected to be relatively coarse, with frequent armoring of bed deposits and frequent bedrock exposures. Although conditions are variable, depending on channel and valley morphology and watershed erosion history, many of the smaller, steeper upland streams important for anadromous fish would be expected to be supply-limited. This expectation is conditioned largely on the high degree of confinement, moderately high slopes, and moderate to intense storm runoff typical of such streams (i.e. factors suggestive of high sediment transport capacity).

The timing and frequency of coarse sediment inputs into stream channels tend to be dominated by mass wasting processes. With the exception of channel erosion, bank erosion and soil creep, mass wasting processes typically generate sediment inputs that are relatively concentrated near the point of entry to the channel network. Landslide deposits in channels typically include abundant coarse and fine sediment and LWD. Deposits may fill existing channels and induce erosion along stream banks. The transport and downstream routing of such coarse sediment budgets have been investigated both in model and field studies of upland rivers (Benda and Dunne, 1997a, 1997b; Lisle et al. 1997 and Lisle et al. in press (re: Floodgate slide)). While it is generally agreed that the local effect is greatest at the point of entry, consistent theoretical statements regarding the magnitude and timing of effects downstream and the governing processes are elusive. Regardless of the specific mechanism, the greatest short-term effects with respect to coarse sediment are localized, with only gradual (over a period of years to decades) translocation of effects (typically increased depth of gravel deposits and changes in size distribution of bed material).

5.3.4 Potential Effects on Covered Species

The potential negative impacts of increased sediment inputs on the covered species differs for coarse versus fine sediments and therefore need to be addressed separately. Coarse sediment in limited amounts that is introduced into the channel along with LWD can contribute positively to aquatic habitat conditions. However, in the most extreme case, landslide deposits may bury a channel reach to depths sufficient to entomb any organisms present such as larval tailed frogs, southern torrent salamanders and salmonid eggs in redds in the streambed. More common and widespread effects resulting from increases in bedload sediment supply may also result in channel aggradation and associated decreases in mean channel depth, decreases in pool depth and more mobile, less stable channels, reducing the quantity of rearing habitat for juvenile salmonids and potentially reducing emergence from redds (Bisson et al. 1992, Sullivan et al. 1987). If water temperatures are not increased, aggradation of the channel due to coarse sediment inputs potentially would have less of an impact on the amphibian Covered Species, because they select for riffle habitat and are generally not found in pools (Diller and Wallace 1996 and 1999; Welsh et al. 1996). Coarse sediment inputs of competent material with a small fraction of fines may actually be beneficial to southern torrent salamanders. Material of this type contains an extensive interstitial network through which the salamanders can move.

Negative effects of excess coarse sediment on pool habitat are believed to be potentially significant for the salmonid Covered Species. Pool abundance and depth has been positively correlated with salmon and trout abundance and density (Bisson et al. 1982; Murphy et al. 1986). Juvenile coho salmon as observed in Simpson's summer population estimates are found almost exclusively within pool habitats (Appendix C7). Pool habitats provide summer rearing habitat, and may act as cool water temperature refugia in the summer (Steele and Stacy 1994). Coarse sediment inputs have the potential to negatively impact the fish Covered Species through infilling of pool habitat and the localized burial of redds. Such habitat modification caused by Covered Activities, could constitute a take of salmonids if it interfered with the ability of those present to shelter or if it destroyed their eggs.

The relatively slow rate of transport of bedload sediment results in relatively persistent effects, depending on local transport rates and the magnitude of the effect. The slow movement of bedload sediment and the tendency for bedload inputs to be concentrated in space in association with landslides suggests that coarse sediment effects may frequently be localized, affecting stream reaches rather than entire watersheds. With the passage of time, assuming inputs of coarse sediment are reduced, negative effects of coarse sediment on salmonid habitat can be expected to dissipate (Sullivan et al. 1987).

The timing and frequency of fine sediment inputs are potentially distinct from timing and frequency of coarse sediment inputs. Both coarse and fine sediment inputs resulting from landslides tend to be concentrated in time and space. More dispersed and chronic inputs of fine sediment are likely, however, owing to widely-dispersed sources and the high frequency of rainfall-runoff events capable of mobilizing fine sediment from sources areas, particularly roads. Most rainstorms are likely to provide sufficient energy to erode and deliver available sediment from road surfaces to streams that are hydrologically connected. Hence, even in relatively dry years when mass wasting processes are insignificant, substantial road surface erosion could occur where conditions are conducive, i.e., sediment is available for erosion because of the condition of the roads and there is a pathway for delivery to streams. This stresses the importance of having well maintained road systems that are hydrologically disconnected from watercourses. Given the propensity for landslide events to be triggered during relatively intense rainstorms, mass wasting episodes tend to be concentrated in a few years over periods of decades at the watershed scale. During the intervening years of relatively low mass wasting, erosion of fine sediment from roads would likely be persistent, potentially magnifying its impact on aquatic habitat.

Negative effects of increased fine sediment input on the Covered Species vary with sediment particle size. Increased inputs of the coarser fraction of fine sediments are associated with increased embeddedness or cementing of the substrate, while the finer suspended load is primarily responsible for high turbidity levels (Chapman 1988). Increases in fine sediments deposition into stream gravels can lead to a reduction in spawning success, reduced food production, and loss of benthic cover for over-wintering juveniles (Hicks et. al. 1991, Wood and Armitage 1997). The larvae and adults of the southern torrent salamander and larval tailed frogs utilize the interstices within gravel and cobble substrate, and are not typically found in streams with embedded gravel and cobble substrates (Bury and Corn 1988a; Diller and Wallace 1996, 1999). Salmon and trout spawn in gravel and cobble substrates, and sedimentation or burial of these substrates would likely result in reduced reproductive success for these species (Chapman 1988). Subsurface flow through redds is essential in providing dissolved oxygen to embryos and carrying away metabolic wastes. Sedimentation can reduce the survival to emergence of the covered embryos by reducing subsurface flow, and by creating sediment 'cap' which prevents hatched fry from emerging (Reiser and White 1988). Accordingly, increased embeddedness caused by increased input from Covered Activities could result in take of salmonids by destroying eggs or fry. Laboratory studies have demonstrated that increases in fine sediment in redds reduces survival to emergence either by entombment or by reducing the supply of oxygenated water to the redd, but field experiments have found more variable effects depending on the experiment, region and other environmental factors (Everest et al. 1987).

Additional effects of excessive sediment inputs of either size class on aquatic habitat include aggradation of stream channels and loss of bank stability, resulting in a wide, shallow channel with low canopy cover, higher water temperatures, and intermittent surface flows in low flow conditions (Swanston 1991). These secondary effects are typically seen in the depositional reaches of streams, making them likely to impact the salmonid Covered Species but not the amphibian Covered Species.

High levels of the finer fraction of suspended sediment (primarily silt and clay) have been found, primarily in laboratory experiments, to have a range of deleterious effects on salmonids. An increase in chronic levels of turbidity can damage the gills of salmonids, impair the ability of fish to locate food, and negatively impact the macroinvertebrate production, which can reduce the growth rate of juvenile salmonids (Bozek and Young 1994; Sigler et. al. 1984; Newcombe and MacDonald 1991). Negative effects of suspended sediment on juvenile salmonids depend on sediment concentration and duration of exposure, and the interaction of these factors is not well understood (Newcombe and MacDonald 1991). In addition, the availability of localized refugia from high suspended sediment concentrations, such as side channels and backwater pools, may also affect both concentration and duration of exposure. Gregory (1993) indicated that suspended sediment may have some beneficial effects as well, such as providing cover from predators. Thus, fine sediment inputs from the Covered Activities could take salmonids by impairing their ability to respire, feed and grow.

It is not known if there are any direct effects of increased suspended sediment or turbidity on the amphibian Covered Species. Simpson speculates that it has the potential to impact the aquatic dependent larval stages of these amphibians in the same manner as was noted above for the salmonids. In addition, suspended sediments could influence the growth of diatoms on the stream's substrate, which is the sole food for larval tailed frogs. Southern torrent salamanders are less likely to be impacted by suspended sediments, because they occur in seeps, springs and the uppermost reaches of streams that are generally not influenced by the downstream transport of fine sediments. However, Simpson believes that it is more likely that increases in suspended sediment (especially the larger particle sizes) would impact the amphibians indirectly by reducing interstices in the substrate and causing substrate embeddedness.

Sediment inputs, both coarse and fine, are absolutely essential to maintain a healthy biotic system. However, excess sediment inputs can have diverse and highly negative impacts. As described in the discussions above, the potential impacts from increased sediment inputs vary depending on the primary particle size involved. The impacts are generally cumulative in nature, especially for the finer particle sizes that can stay suspended in the water column and potentially impact regions at great distances downstream of the sediment source. The life history stage of the Covered Species that are potentially impacted by various types of sediment inputs is also variable, but there is the potential for all life history stages to be negatively impacted in a manner resulting in take. Increased sediment inputs can produce a myriad of negative impacts on habitat, such as increased pool filling, embeddedness, increased temperature and turbidity can potentially result in direct mortality, and decreased survival rates of various life history stages of the Covered Species, particularly in early life stages. Such impacts of direct take, and more importantly, changes in population demographic parameters, may result in local population declines. Such declines could negatively affect the regional populations of the Covered Species.

5.4 POTENTIAL EFFECTS ON LWD RECRUITMENT

5.4.1 Potential Effects of Covered Activities

Timber harvest and the presence or construction of roads in riparian areas may result in a decline in the recruitment of LWD and a resulting reduction of in-channel LWD. Timber harvest in riparian zones removes trees that could otherwise become in-channel LWD. Roads in riparian zones may reduce potential LWD by simply removing their surface area from tree production, and also through intercepting trees which fall toward the channel. Trees, which fall across roads, must be cleared, and traditionally these trees have been removed for commercial use where possible. This practice essentially eliminates potential LWD that is separated from a stream by a maintained road. See Appendix E.

In Simpson's view, harvesting trees that are potential sources of future LWD (i.e., trees located in a position that, if left in place, could grow to sufficient size to perform LWD functions and are located where they could be recruited to a watercourse) would not cause a "take" as it does not constitute a significant habitat modification or degradation which actually causes the death or injury of fish or wildlife by significantly impairing essential behavioral patterns (any injury would be so far into the future as to be speculative). Nevertheless, Simpson recognizes that such an action has the potential to result in potentially significant long term negative impacts (other than "take") on future habitat conditions and the ability of the local salmon stocks to maintain and recover. Simpson also believes that maintaining and improving LWD recruitment provides a significant conservation benefit for all the Covered Species. Accordingly, for purposes of developing and prioritizing conservation measures for this Plan, Simpson has (a) addressed the potential adverse environmental effects of removing possible sources of future LWD as if they are comparable in relative significance to the potential impacts of actual take, and (b) included in the proposed conservation strategy a number of measures designed to minimize and mitigate these impacts and to conservation benefits associated with maintenance and improved recruitment of LWD.

5.4.2 Potential Effects on Covered Species

In-channel LWD is recognized as a vital component of salmonid habitat, and to a lesser extent, but still important to the amphibian Covered Species. The physical processes associated with LWD include sediment sorting and storage, retention of organic debris, and modification of water quality (Bisson et al. 1987). The biological functions associated with LWD structures include important rearing habitats, protective cover from predators and elevated stream flow, retention of gravels for salmonid redds, and regulation of organic material for the in-stream community of aquatic invertebrates (Murphy et al. 1986; Bisson et al. 1987). Decreased supply of LWD can result in (Hicks et. al. 1991 as cited by Spence et al. 1996):

- reduction of cover,
- loss of pool habitats,
- loss of high velocity refugia,
- reduction of gravel storage, and
- loss of hydraulic complexity.

These changes in salmonid habitat quality can lead to increased predator vulnerability, reduction of winter survival, reduction in carrying capacity, lower spawning habitat availability, reduction in food productivity and loss of species diversity.

In headwater streams, LWD is also known to dissipate hydraulic energy, store and sort sediment, and create habitat complexity (O'Connor and Harr 1994). Creating and providing cover for pools, a primary function of LWD for salmonids, may be of limited benefit to the headwater amphibian Covered Species since torrent salamanders and larval tailed frogs prefer riffle habitats (Diller and Wallace 1996 and 1999; Welsh et al. 1996). The primary benefit of LWD to the amphibians is the creation of suitable riffle habitat through the storing and sorting of sediment. In addition, LWD that is perched a short distance above the streambed will often form a dam composed of coarse sediment and small woody debris through which water percolates. In streams that are otherwise too embedded with fine sediments to be used by torrent salamanders, this appears to form the only habitat that still supports the species (Diller, pers. comm.). There is circumstantial evidence that these same sites are utilized for egg laying by tailed frogs, but searching such sites is too destructive to adequately investigate the phenomenon (Diller, pers. comm.).

The decline of recruitment of potential LWD from riparian zones can be expected to reduce LWD recruitment to streams for decades following timber harvest of riparian areas. High in the watershed, the potential impacts would be primarily localized, but in larger streams lower in the watershed, LWD can be transported during higher flow events and the impacts may be cumulative. A decline in pool density, pool depth, in-stream cover, gravel retention, and sediment sorting are likely to result if LWD recruitment is reduced. These habitat changes may reduce the growth, survival, and total production of salmonids as well as the amphibian species (Steele and Stacy 1994; Murphy et al. 1986). Given that LWD is likely critical to provide habitat and cover for juvenile salmonids in both summer and winter, survival rates of these life history stages may be limited by the amount of LWD in some streams. Such potential impacts that reduce survival rates of key life history stages of the Covered Species may result in local population declines. Such declines could negatively affect the regional populations of the Covered Species.

5.5 POTENTIAL FOR EFFECTS FROM ALTERED THERMAL REGIMES AND NUTRIENT INPUTS

5.5.1 Potential Effects of Altered Riparian Microclimate

The riparian microclimate has potentially important indirect effects on the salmonid Covered Species and aquatic forms of the amphibian Covered Species through alteration of water temperature, which will be discussed in the following Section. However, the riparian microclimate also has potentially important direct effects on the adult forms of the amphibians. Reduction of riparian overstory canopy through timber harvesting could result in increased levels of incident solar radiation reaching the stream and riparian zone during the day and reduced thermal cover at night (Welch et al. 1998). It could also increase exposure to wind in the riparian areas due to an edge effect from an adjacent harvest unit with the overall net effect of increasing daily fluctuations in air temperature and relative humidity. Studies done in areas outside the coastal influence of the 11 HPAs indicate that microclimatic edge effects can be detected as much as 240 meters (787 feet) from the edge of a clearcut (Chen 1991). However, the greatest attenuation of edge effects on microclimatic changes occurs within the first 30 meters (98 feet) of the buffer (Ledwith 1996). Although the impact of altered riparian vegetation on the microclimate is ameliorated by the cool coastal climate in the region, reduction of riparian cover due to timber harvesting has the potential to cause greater daily and seasonal fluctuations in the microclimate of the riparian areas.

In addition, increased coarse sediment inputs from management activities, particularly when it occurs in the form of debris torrents, can result in widening of the channel and loss of streamside vegetation (Swanston 1991). Just as in overstory canopy loss, this has the potential to alter the riparian microclimate by increasing daily fluctuations in air temperature and relative humidity. It is unlikely that increases in air temperature with corresponding decreases in relative humidity during the day would directly impact the amphibians, because the adults are not surface active during the day. However, the corresponding drying effect of increased air temperature and decreased relative humidity could result in the loss of some daytime refugia habitat and nighttime foraging sites. It is also possible that the reduction of thermal cover at night may impact the ability of adults to forage at night.

5.5.2 Potential Effects of Altered Water Temperature

Loss of riparian overstory canopy through timber harvesting and increased coarse sediment inputs from management activities could result in alteration of the riparian microclimate as described above. However, changes in the riparian microclimate will also result in corresponding changes in the daily water temperature regime. In addition, both reduction of overstory canopy and increased coarse sediment inputs can result in altered water temperature through direct mechanisms. Removal of the riparian canopy will result in elevated summer water temperatures, often in direct proportion to the increase in incident solar radiation that reaches the water surface (Chamberlain et al. 1991). For a given exposure from solar radiation, water temperature increases directly proportional to the surface area of the stream and inversely proportional to stream discharge (Sullivan et al. 1990). Exposed channels will also radiate heat more rapidly at night. In addition, increased sediment inputs that results in aggradation will result in a wider and shallower channel that gains and losses heat more rapidly. Therefore, reduction of riparian vegetation and aggradation of a channel act synergistically to cause greater daily and seasonal fluctuations in water temperatures.

Increased water temperatures can have negative impacts on the salmonids (Beschta et al. 1987) as well as the amphibians. Potential impacts to salmonids from increased stream temperatures include (Hallock et al. 1970; Hughes and Davis 1986; Reeves et al. 1987; Spence et. al., 1996):

- reduction in growth efficiency,
- increased disease susceptibility,
- changes in age of smoltification.
- loss of rearing habitat, and
- shifts in the competitive advantage of salmonids over non-salmonid species.

Although the specific mechanisms are not known, many of the same physiological or ecological factors associated with elevated water temperatures presumably exist for the amphibian species, which have temperature thresholds below those of the fish Covered Species.

Although elevated water temperatures can be a relatively localized phenomenon, this factor generally functions in a cumulative manner throughout a sub-basin or watershed. The impact of elevated water temperature also tends to be cumulative on a temporal scale, such that short-term increases are less likely to be harmful compared to more chronic increases in water temperature. The potential harm or death associated with this factor would primarily influence the juvenile salmonids and larval amphibians during summer and early fall. Take of Covered Species could occur as the result of temperature increases causing the impairment of essential functions and injury or mortality. The potential impacts of such taking include potential reductions in the local or regional populations of the Covered Species and could affect a possible need to list currently unlisted Covered Species under the ESA in the future.

5.5.3 Potential Effects of Altered Nutrient Inputs

Unlike lentic systems and the mainstem of many rivers in which runoff from agricultural, suburban, industrial and other areas lead to eutrophication, the portion of lotic systems throughout the Pacific Northwest and Northern California in which salmonids spawn and rear are thought to be naturally oligotrophic due to low levels of nitrogen (Allan 1995; Triska et al. 1983). However, additions of nitrogen in these systems will only result in limited increases in primary productivity, because most of these streams, especially heavily shaded lower order channels, are also limited by light (Triska et al. 1983). While autochthonous inputs (derived from within the aquatic system through photosythesis) are important in higher order channels, much of the energy and nutrients in lower order channels (where many salmonids rear) comes from allochthonous inputs (derived from outside the aquatic system typically through detrital inputs). One of the most important sources of detrital inputs in streams throughout the Northwest comes from red alder, because it is readily available to the aquatic invertebrate community and its leaves are high in nitrogen (Murphy and Meehan 1991; pers. comm. K. Cummins, Humboldt State

University). The fact that red alder fixes atmospheric nitrogen also has important implications for increasing the total available nitrogen in these potentially oligotrophic lotic systems. In contrast to red alder leaves that can be 50% decomposed in less than 2 months, Douglas-fir needles may take over 9 months to reach the same level of decay and have far less nitrogen. Woody debris, even twigs and small branches, has limited nutritional value to streams because it decays so slowly and is very low in nitrogen (Murphy and Meehan 1991). Another potentially important source of nutrients to streams comes from annual spawning runs of anadromous salmonids. Reduced ocean-derived nutrients to stream and riparian ecosystems due to declines in salmon returns in many regions have received considerable attention in recent years (AFS: Nutrient Conference 2001). This has lead to numerous studies looking at the potential benefits of artificially increasing the productivity ("jump-starting") of these systems through the addition of salmon carcasses or other sources of nutrients.

Reduction of riparian vegetation due to timber harvest is likely to increase productivity of streams in several ways. Increased incident solar radiation would likely increase periphyton production (unless it is limited by nitrogen), which may increase the abundance of invertebrates and fish due to an enhanced quality of detritus. The mechanism of this increase is tied to the algae, a higher quality food than leaf or needle litter, which increases the abundance of invertebrate collectors, which in turn, can increase the abundance of predators such as juvenile salmonids (Murphy and Meehan 1991). In addition, timber harvest in riparian areas may reduce the number of conifers and increase deciduous vegetation such as red alder. Therefore, with increased input of nutritionally rich leaf detritus compared to conifer needles, productivity of the stream may increase. Of course, the salmonid response would only be realized if the alteration of the riparian vegetation did not also lead to adversely high water temperatures. An increase in stream productivity may also not ultimately result in increased production of salmonids, because it will primarily benefit summer rearing populations when the "bottleneck" (i.e. limiting factor) for many salmonid streams is winter rearing habitat (Murphy and Meehan 1991).

Larval tailed frogs feed exclusively on diatoms that grow on the surface of the stream's substrate (Metter 1964). Growth of the diatoms is influenced by factors such as sunlight, water temperature and nutrients, but there have been no studies to determine if diatomaceous growth is ever limiting for larval tailed frogs. As a result, it is not possible to speculate on how altered nutrients may influence this life history stage of tailed frogs. The adult frogs presumably feed in the riparian zone, but little is known of their foraging ecology and it would not be possible to speculate on how altered nutrients in the stream might influence the adults. Larval and adult southern torrent salamanders feed primarily on small aquatic invertebrates whose numbers would be influenced by detrital inputs. However, it is not known if food is ever limiting for this species such that changes in aquatic invertebrates would influence survival or growth of individual salamanders.

Take of Covered Species could occur as the result of temperature increases causing the impairment of essential functions, if injury or mortality resulted. The potential impacts of such taking include potential reductions in the regional populations of the Covered Species.

The impacts of altered nutrient inputs would most likely be subtle and difficult to predict. The greatest potential impact would be to juvenile salmonid populations that need to reach some threshold in size before smoltification and out-migration can occur.

Decreases in nutrient inputs would not likely result in direct harm, but they may reduce survival during the freshwater rearing period. In addition, ocean survival would likely be decreased if smolts out-migrate at smaller sizes. However, it would be difficult to determine that any management activities were responsible for take as the result of altered nutrients.

5.6 OTHER POTENTIAL EFFECTS

5.6.1 Potential Effects of Barriers to Fish and Amphibian Passage

Culverts can become impassable barriers to both adult and juvenile anadromous and resident salmonids (Evans and Johnson 1980). Culverts can become barriers to anadromous fish by:

- creating high flow velocities at the inlet, outlet or within the culvert,
- creating excessive height from downstream pool into the culvert outlet,
- providing in-adequate water depths for upstream passage,
- lacking resting pools at the culvert inlet, outlet, or within the culvert.

Juvenile salmonids have been observed dispersing upstream and downstream in response to various environmental factors. These include seeking refuge: from high stream temperatures; high flow conditions and predation; or seeking lower population densities with more favorable food and cover conditions (Bustard and Narver 1975, Cederholm and Scarlett 1981, Everest 1973, Fausch and Young 1995, Gowan et al. 1994, Hartman and Brown 1987, Shirvell 1994). Because adult and juvenile fish have different swimming and jumping abilities, a culvert that may pass adults could be a barrier to juvenile fish. (See Appendix E.)

The potential effects of these barriers on adults of the salmonids include blocking or delaying access to spawning grounds (Evans and Johnston 1972). The potential effects of these barriers on juvenile salmonids include significantly reducing available rearing and foraging habitat and reducing or eliminating low velocity refugia during high winter flows, possibly reducing survival of overwintering juveniles. The potential effects of installing and using culverts in areas where Simpson operates on adult and juvenile fish passage could lead to fish mortality or impairment of breeding and could constitute take. The impact of such take could include reductions in survival and production of fish in affected watersheds.

It is not known if culverts have the potential to affect the amphibian species. It is likely that they act as barriers to the larval forms but not the adults. Whether or not this has an impact on the populations is not known since the headwater amphibians are thought to have limited vagility.

Culvert failures due to blocking, undersize culverts, or poor maintenance, can result in mass wasting events that deliver large volumes of sediment to watercourses. Culvert related mass wasting events are accounted for in the figures and papers cited in the discussion of road-related sediment inputs and the potential effects of sediment on the Covered Species.

5.6.2 Potential for Direct Take from Use of Equipment

Some Covered Activities entail the use of equipment that could directly take Covered Species. Events that potentially could result in take include, but are not restricted to:

1. Operation of heavy machinery in streams during other Covered Activities, such as construction of watercourse crossings or stream enhancement work;
2. The falling and yarding of timber and pre- and post-harvest management activities (including construction and maintenance of roads) in stands adjacent to streams;
3. Drafting of water from watercourses for dust abatement; and
4. Incidental drippage or leakage of petroleum products such as fuel and lubricants from equipment used during other Covered Activities.

Such events have the potential to injure or kill adults, juveniles, larvae, and/or eggs of the Covered Species at the location where the impact occurs. These events would be highly stochastic and isolated in nature. As a result, the taking would have very localized impacts and would not be likely to cause even local declines in populations of the Covered Species.

5.7 SUMMARY OF POTENTIAL IMPACTS OF TAKE, INCLUDING CUMULATIVE IMPACTS

Simpson has identified cumulative effects issues associated with the impacts of take resulting from the Covered Activities described in Section 2.2.4 of the Plan related to timber management.

Cumulative impacts are relevant in the Services' issuance of the ITP/ESP, conducting the ESA section 7 internal consultation as part of permit issuance, and preparing an EIS under the National Environmental Policy Act ("NEPA"). Generally, cumulative impacts are the incremental impact which results from the federal action, i.e., approving the incidental take permits under the conditions of approval described in the AHCP/CCAA, when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

In the case of issuance of an ITP/ESP, the cumulative effects issue is whether the incremental impacts of take, when combined with impacts from other projects, will appreciably reduce the likelihood of survival and recovery in the wild of any Covered Species (the "jeopardy" standard); if so, the AHCP/CCAA would fail one of the significant approval criteria for both ITPs and ESPs.

Simpson evaluated cause-and-effect relationships among the Covered Activities, take of the Covered Species and the impacts of take, including cumulative impacts. The magnitude and significance of cumulative effects were considered, alternatives developed, and specific conservation measures incorporated into the Operating Conservation Plan to avoid, minimize or mitigate significant cumulative environmental effects. Where substantial uncertainties remain or multiple resource objectives exist, adaptive management provisions allow for flexible project implementation.

A significant premise of the AHCP/CCAA is that the Plan's conservation measures not only fully minimize and mitigate individual impacts of take by category and type of impact, but that Simpson's activities and management practices under the Operating Conservation Program outlined in Section 6.2 of the Plan will result in significant improvements in habitat conditions for the species. In Simpson's view, the Plan contributes to the maintenance and restoration of properly functioning habitat and, thereby, contributes to the recovery of the listed Covered Species. In other words, this Plan is designed expressly to exceed the requirements for HCPs and to meet the requirement for CCAAs (that a CCAA must contribute to efforts to reduce the need to list currently unlisted Covered ESP Species by providing early conservation benefits to those species).

In the context of cumulative impacts analysis, the incremental effect on the Covered Species of implementing the AHCP/CCAA will be positive. Therefore, the AHCP/CCAA's positive incremental effect will not cause or contribute to negative "cumulative effects." Simpson used the following analytical mechanism to develop a Plan that supports this conclusion. Simpson analyzed and described relevant baseline environmental conditions of the 11 HPAs in the Plan. As part of this analysis, Simpson identified those habitat conditions or factors that are "limiting" for the Covered Species in each of the HPAs. In any population of animals, there are one or more biotic or abiotic factors acting on one or more life stages that ultimately limit the growth of the population. If a single limiting factor acts on a single life stage, this can be viewed as the limiting factor or "bottleneck" for the population or species. For example, over-wintering habitat for juveniles has been frequently indicated as the likely bottleneck or limiting factor for coho salmon in their freshwater habitat (Murphy and Meehan 1991). If this is the case, then other factors that influence different life stages may have no impact on the production of coho from a given sub-basin or watershed. As an example, a hypothetical sub-basin may have 10,000 fry emerge from the spawning gravels during an average year, but there is only enough over-wintering habitat to support 1000 juvenile coho. In this example, survival of eggs and alevin could decline by 50%, but this would not cause a decline in the local population because there would still be a surplus of fry relative to the available habitat for the juveniles. Therefore, the concept of a population bottleneck or limiting factor implies that, potentially, there are factors that may result in harm or death for individuals at certain life history stages that would not result in an impact for the population, because the life stage effected is not limiting.

As described above, there are a variety of factors that have the potential to cause take of the Covered Species. Simpson has little site-specific data that would allow Simpson to determine quantitatively which of these factors are most likely limiting in any given watershed within the 11 HPAs. The matter is further complicated by the potential for various factors to interact synergistically making it even more difficult to predict the impact of changes in a given factor. For example, limited increases in water temperature may be beneficial, if there is ample food, because it will increase growth rates of the juvenile salmonids. However, the same increase will be detrimental when food is limited, because the increased water temperature will increase basal metabolic rates and reduce the amount of their ingested food that will go into growth.

Although the complex nature of these potential limiting factors makes the analysis difficult, Simpson's assessment of the HPAs (see Section 4.4) indicates that certain factors have a greater probability of being limiting in most HPAs. Through this analysis, Simpson has analyzed the potential for Covered Activities to cause or contribute to these limiting factors. In addition, Simpson analyzed baseline environmental conditions by evaluating site-specific data and ranking salmonid life history stages in terms of potential to represent the population bottleneck and then reviewed the potential for individual Covered Activities to cause environmental effects that themselves might not cause significant habitat impairment or cause take but, when combined with other similar effects that are closely related temporally and spatially, could cause take of Covered Species or cause or contribute to adverse habitat conditions for the Covered Species.

Based on this analysis, Simpson believes that available summer and winter rearing habitat is most likely to be limiting for the salmonids in most HPAs. If this is true, the interaction of excess coarse sediment input and a lack of LWD would have the greatest potential to negatively impact the local and regional population of these species. Excess coarse sediment inputs without LWD would aggrade the channels and eliminate high quality pool and backwater habitat for juvenile salmonids during both summer and winter. This could occur on a relatively localized scale in smaller sub-basins, but in larger systems (generally third order and larger), the effects would tend to be cumulative due to the capacity for these systems to transport coarse sediment during higher flows. Fine sediment inputs are less likely to be limiting, because it tends to have the greatest impact on spawning success. However, given the high potential for fine sediments to be transported downstream, the cumulative effect of multiple sources of fine sediment inputs throughout a sub-basin over extended periods could seriously impair the feeding efficiency of juvenile salmonids and cause local or regional population declines.

Excess sediment inputs, both coarse and fine, have the greatest potential to limit habitat and deter conservation efforts for the benefit of the amphibian species. However, rather than eliminating pool formation, the greatest impact would be the embedding of riffle habitat that eliminates the interstices in the substrate on which the larval phases of these species depend. The amphibian species do not appear to be as directly depend on LWD compared to the salmonids, but LWD does result in sorting of the substrate, which tends to create areas of suitable riffle habitat, even in a stream that otherwise suffers from excess sediment inputs. Being higher in the watershed, the amphibians are generally less impacted by cumulative effects relative to the salmonid species. In particular, the southern torrent salamander is typically found in the uppermost reaches of a watershed and is generally only sensitive to direct impacts.

As discussed above, altered hydrology has the potential to impact the Covered Species in a variety of ways that could be both positive and negative. Simpson does not believe that altered hydrology by itself could be a limiting factor for any of the Covered Species. However, it has the potential to exacerbate a situation in which there is excess sediment inputs with too little LWD present. Since it operates in a cumulative manner, it would also be necessary to alter the hydrology of a large portion of a sub-basin or watershed before the magnitude of the response would be large enough to impact the Covered Species.

Water temperature, as a single factor, has the potential to be a limiting for all of the Covered Species. The suite of Covered Species are all considered “cold water adapted” and each have relatively discrete upper thermal limits above which harm or death occurs. However, streams throughout the 11 HPAs generally do not have temperatures that are at or near these upper thresholds. A few isolated streams or stream reaches have water temperatures that could cause local declines in populations of the Covered Species, but it is not likely to be potentially responsible for regional declines.

Barriers to salmonid movements, both partial and complete, can limit local populations when all other habitat factors are good. As a result, the cumulative impact of barriers has the potential to limit populations over both a local and regional scale. However, within the 11 HPAs, anthropogenic barriers are relatively isolated so the impact of these barriers tends to only have localized impacts. As noted above, the mechanisms of direct take tend to only have localized impacts that would not likely to result in even local impacts on populations of the Covered Species.

As this analysis reflects, the complicated nature of these potential limiting factors makes it impossible to definitively assess the extent of the potential impact of take or the Covered Activities associated with any given factor. Therefore, Simpson's conservation strategy addresses all the factors as if they are limiting in each HPA; Simpson designed measures to be implemented during the course of the Plan that will provide for significant improvements in each of those factors over baseline conditions in all areas In other words, with a few exceptions where HPA-specific measures have been proposed, the measures designed to address each type of limiting factor will be applied throughout all 11 HPAs as if that factor is in fact limiting throughout the Initial Plan Area Under such conditions, the Plan will not result in negative cumulative impacts. For these reasons, the incremental effect of Plan implementation will be positive compared with existing baseline conditions and will result in generally improving habitat conditions for native salmonids over the term of the Permits in all HPAs. Therefore, Plan implementation will not result in negative cumulative effects